US006374636B1

# (12) United States Patent
**Thonnelier et al.**

(10) **Patent No.: US 6,374,636 B1**
(45) **Date of Patent: Apr. 23, 2002**

(54) **BATH REBOILER-CONDENSER AND CORRESPONDING AIR DISTILLATION PLANT**


(75) Inventors: **Jean-Yves Thonnelier**, Voisins le; **Jean-Yves Lehman**, Maisons; **Jean-Renard Brugerolle**, Paris; **Etienne Werlen**, Versailles, all of (FR)

(73) Assignee: **L'Air Liquide, Societe Anonyme pour l'Etude et l'Exploitation des Procedes Georges Claude**, Paris Cedex (FR)



( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1 days.

(21) Appl. No.: **09/665,895**

(22) Filed: **Sep. 20, 2000**

(30) **Foreign Application Priority Data**

Sep. 21, 1999 (FR) .......................................... 99 11777

(51) **Int. Cl.**[7] .................................................. **F25S 3/04**
(52) **U.S. Cl.** ........................................................ **62/643**
(58) **Field of Search** .......................... 62/646, 643, 903; 165/110, 115


(56) **References Cited**

U.S. PATENT DOCUMENTS


| | | | | | |
|---|---|---|---|---|---|
| 3,992,168 | A | * | 11/1976 | Toyama et al. | 62/42 |
| 4,715,433 | A | * | 12/1987 | Schwarz et al. | 165/110 |
| 5,122,174 | A | * | 6/1992 | Sunder et al. | 62/24 |
| 5,755,279 | A | * | 5/1998 | Sweeney et al. | 165/115 |
| 5,775,129 | A | | 7/1998 | Satchell, Jr. et al. | |
| 5,868,199 | A | * | 2/1999 | Lavin | 165/166 |

* cited by examiner



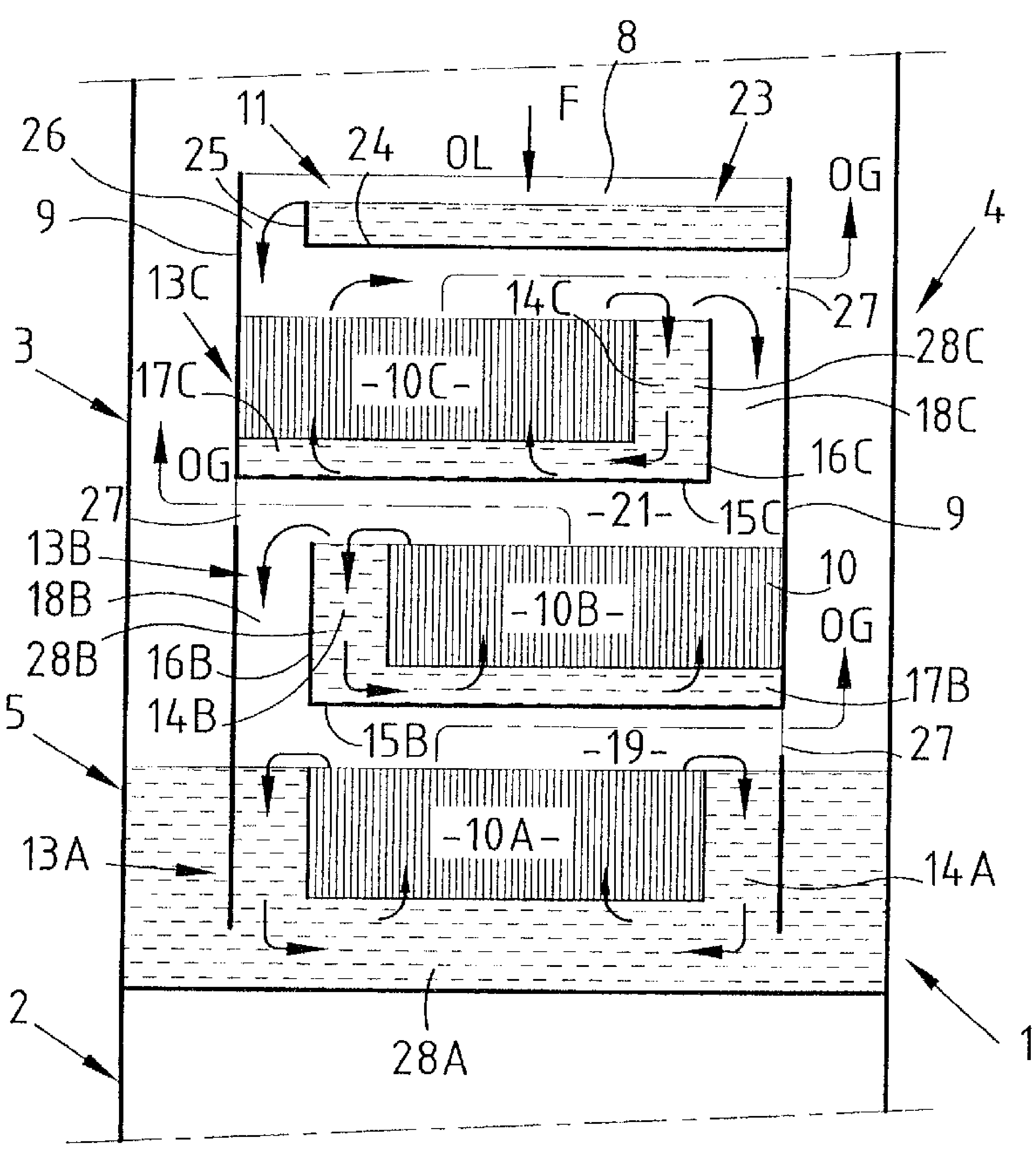
*Primary Examiner*—William Doerrler
*Assistant Examiner*—Malik N. Drake
(74) *Attorney, Agent, or Firm*—Young & Thompson


(57) **ABSTRACT**


This bath reboiler-condenser (**4**), of the brazed plate type, includes vaporization passages (**11**) subdivided into a plurality of stacked vaporization regions (**13**A to **13**C) each of which is immersed in a partial height bath (**28**A to **28**C), and means for feeding the top vaporization region (**13**C) with liquid. The vaporization regions (**13**A to **13**C) are spaced vertically and each region is entirely open at its top and bottom ends.

Application to the main reboiler-condensers of double air distillation columns.


**18 Claims, 6 Drawing Sheets**



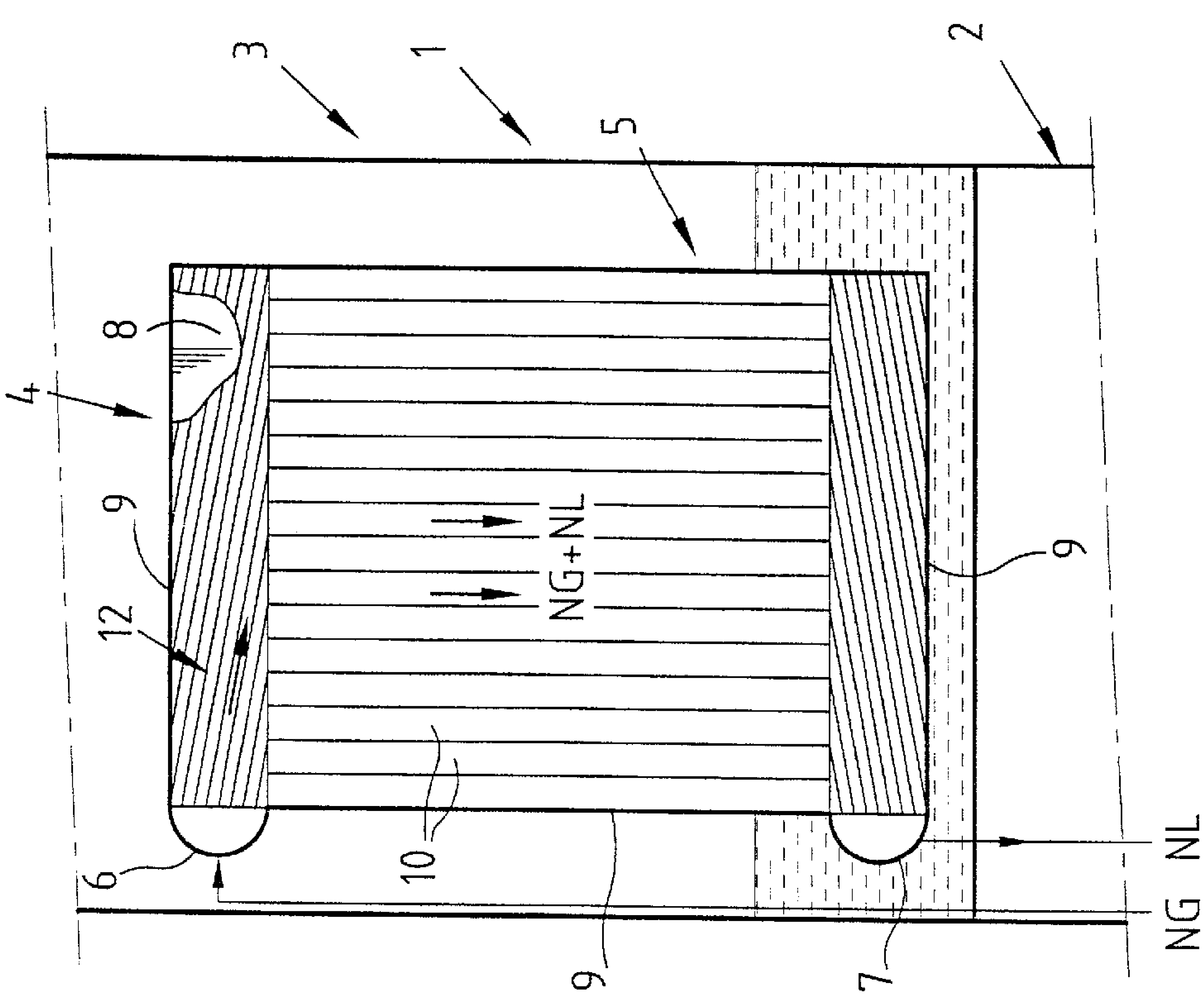


FIG.2

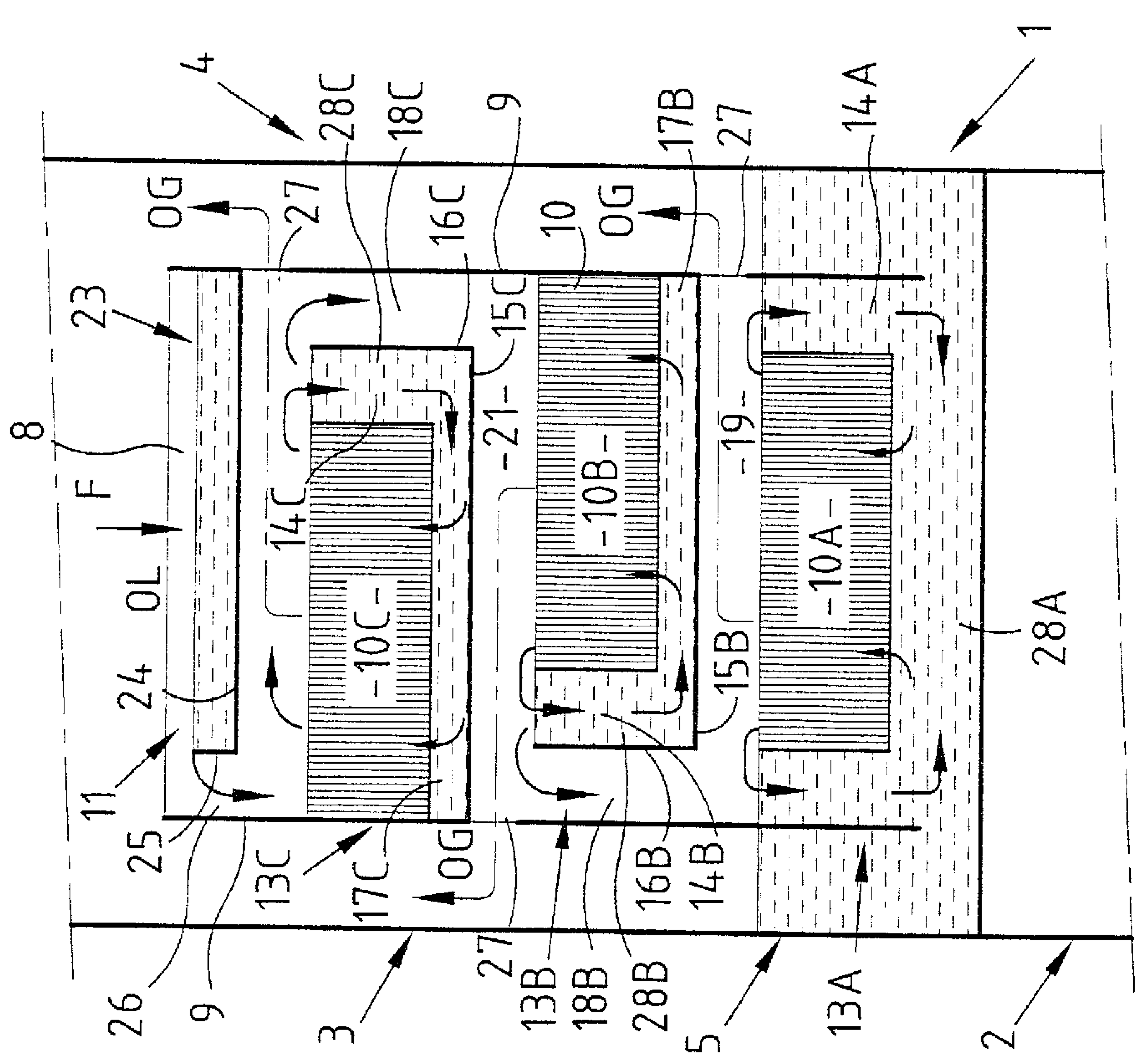


FIG.1

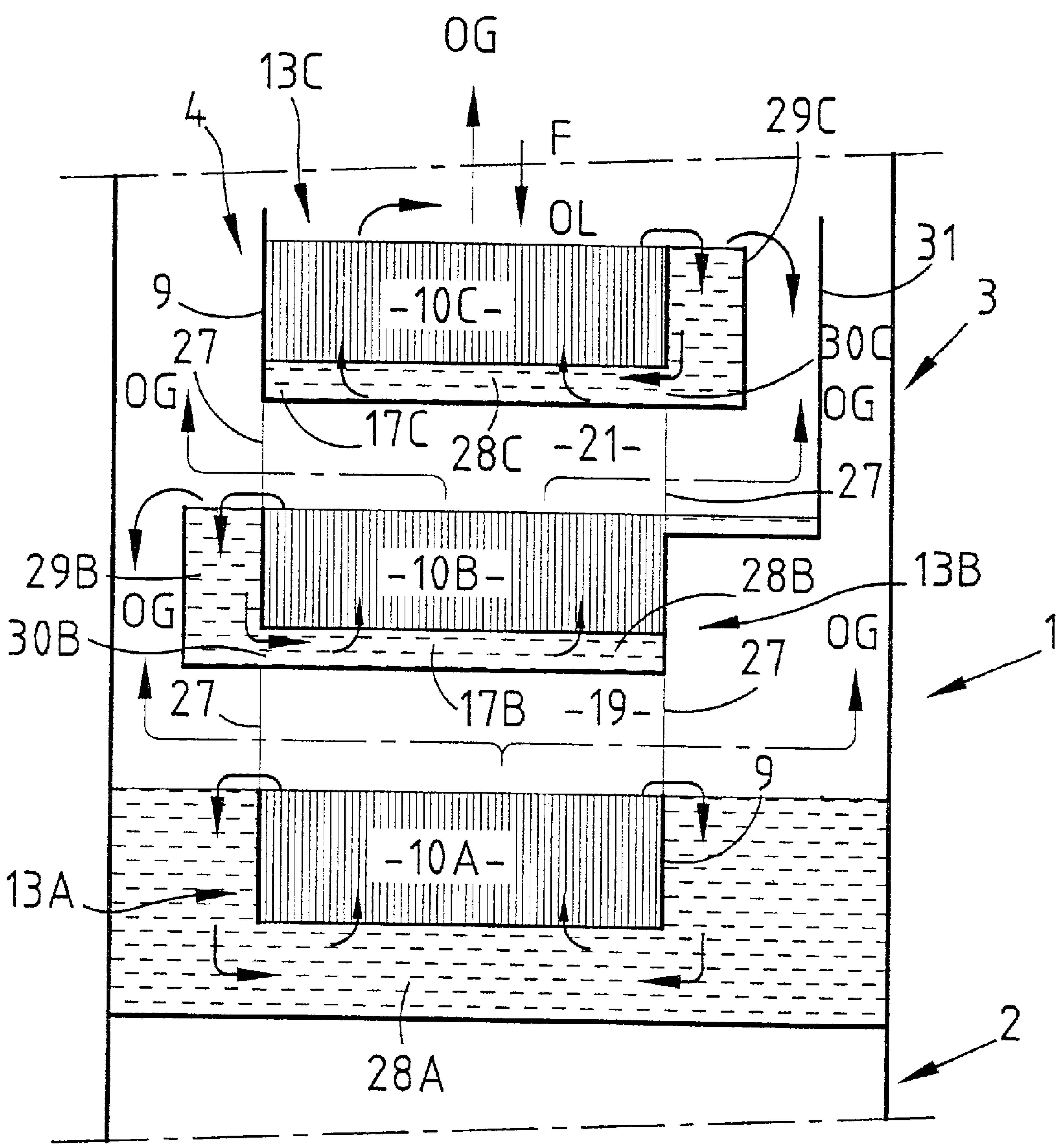

OG
13C
4
F
29C
OL
31
9
-10C-
3
27
30C
OG
OG
17C
28C
-21-
27
-10B-
29B
28B
13B
OG
1
30B
OG
27
27
17B
-19-
9
-10A-
13A
28A
2

FIG.3

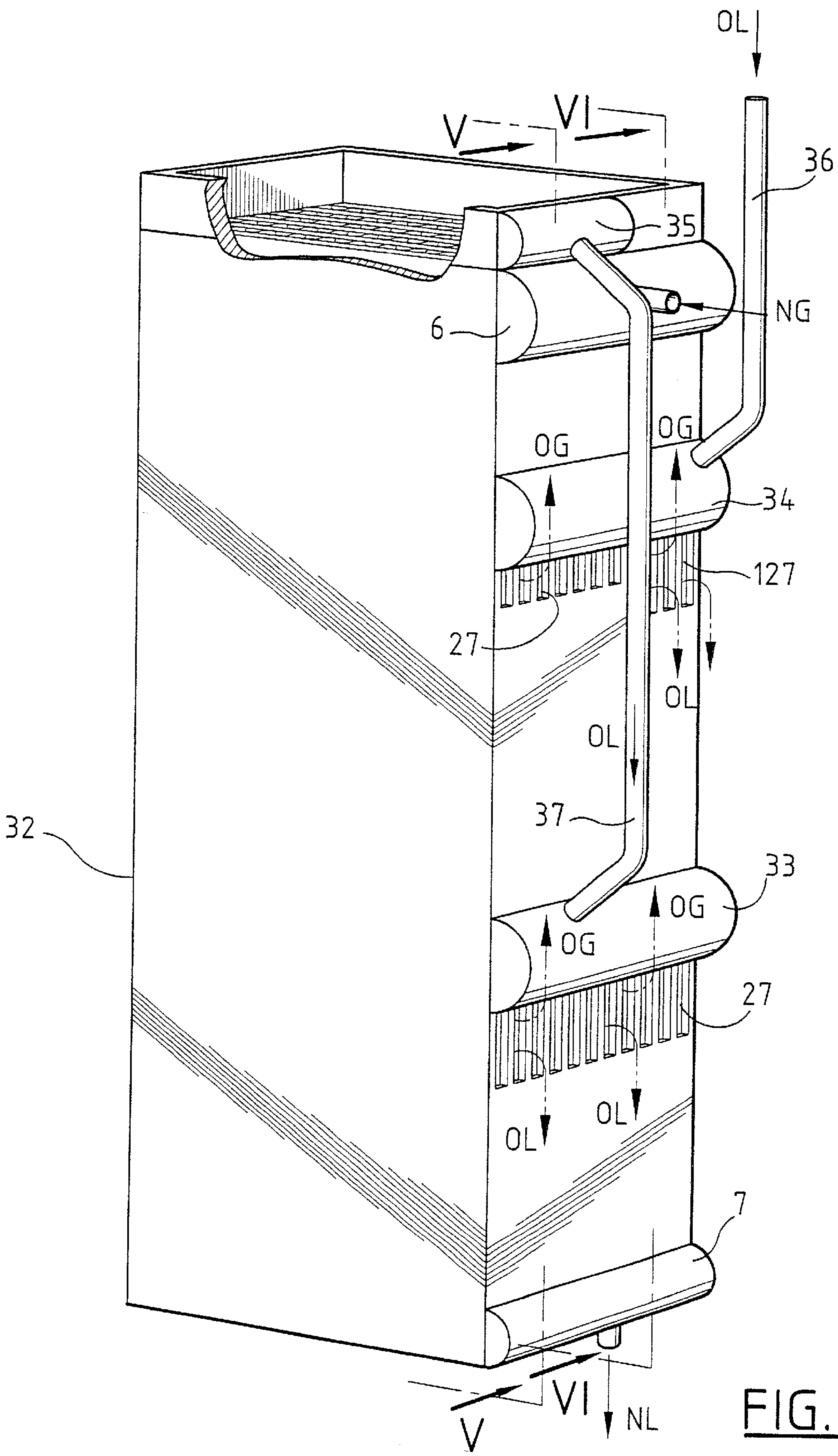



FIG. 4

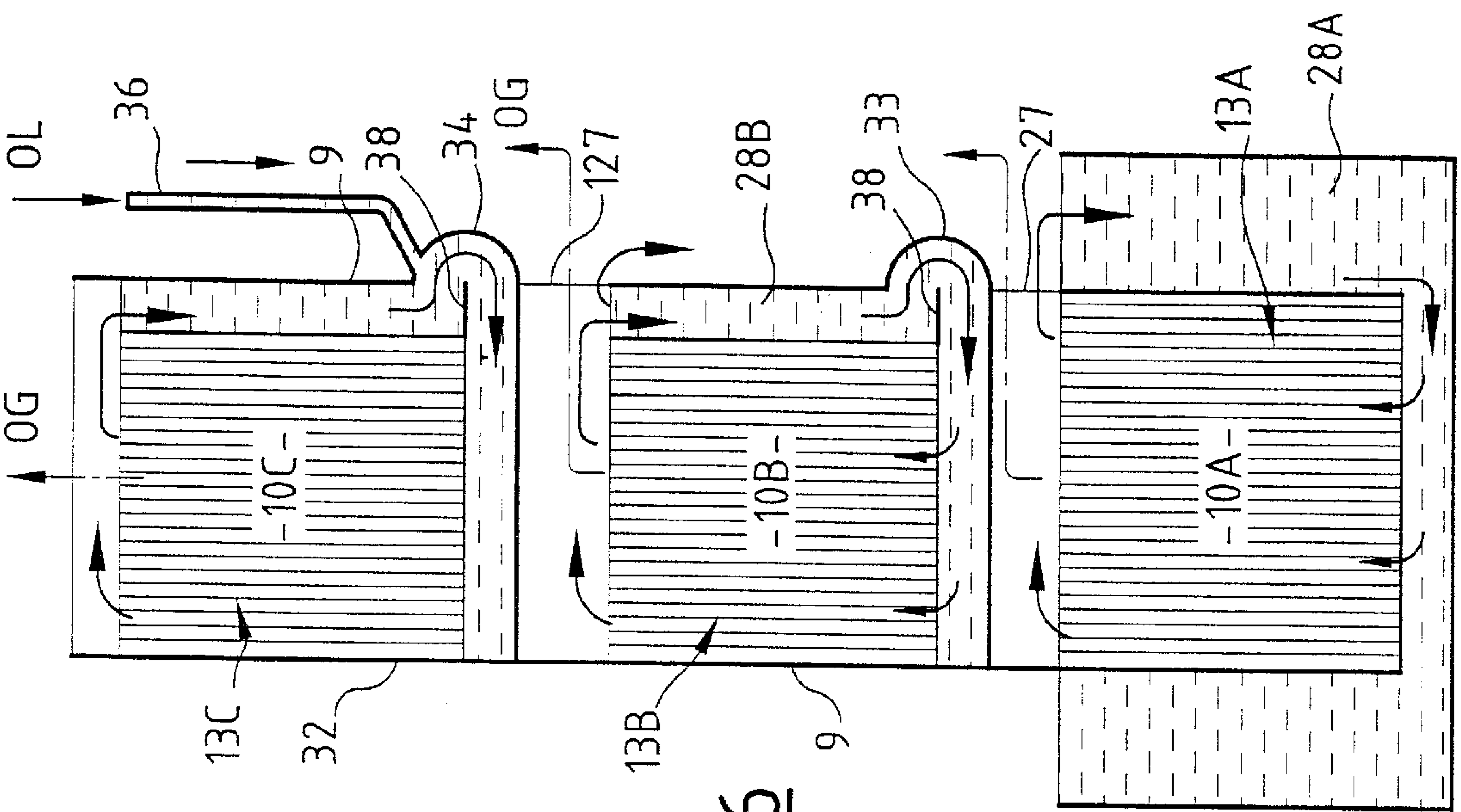

OL
36
9
38
34
OG
127
28B
38
33
27
13A
28A
OG
-10C-
-10B-
-10A-
13C
32
13B
9

FIG.6

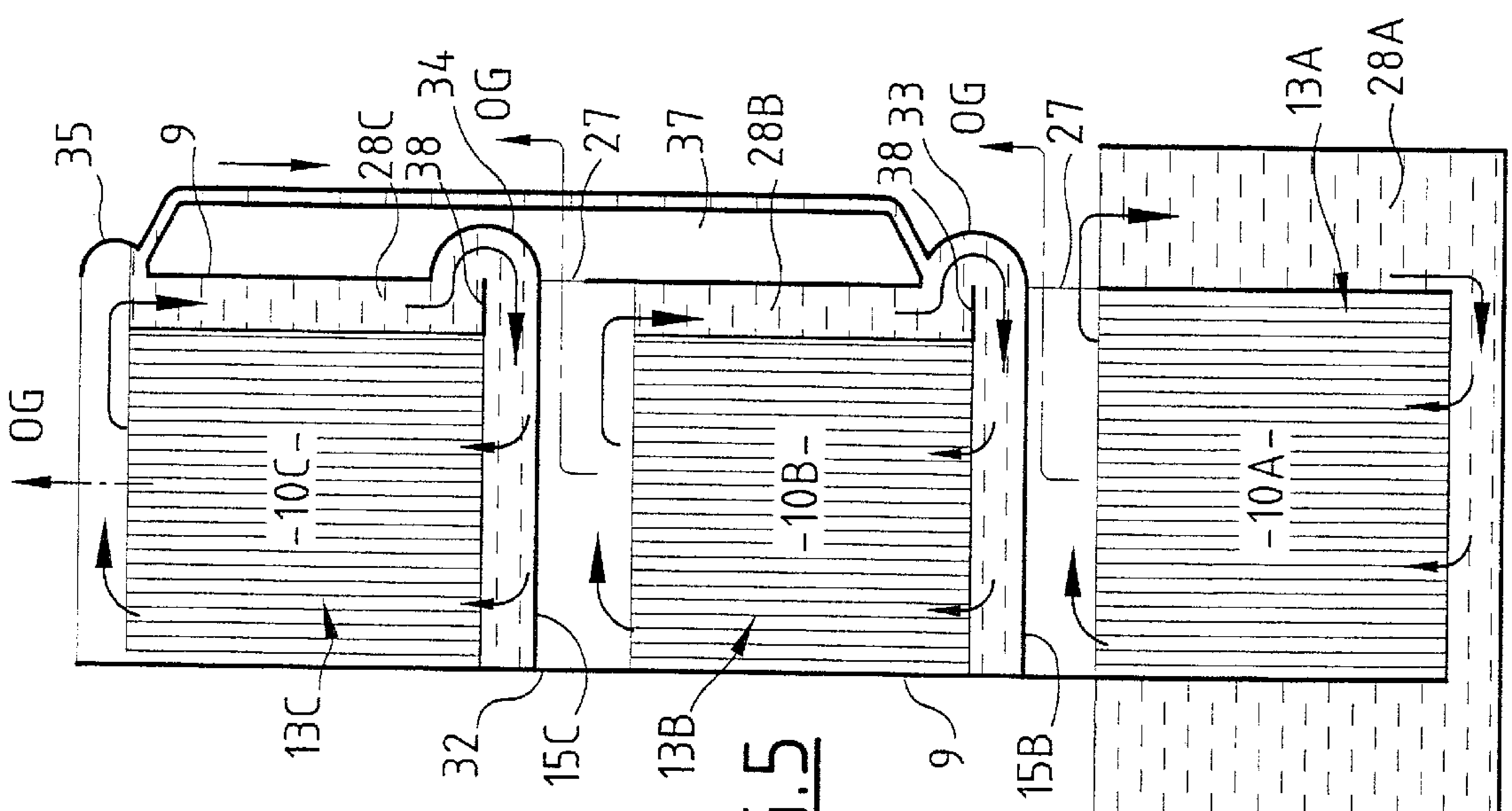

35
9
28C
38
34
OG
27
37
28B
38
33
OG
27
13A
28A
OG
-10C-
-10B-
-10A-
13C
32
15C
13B
9
15B

FIG.5

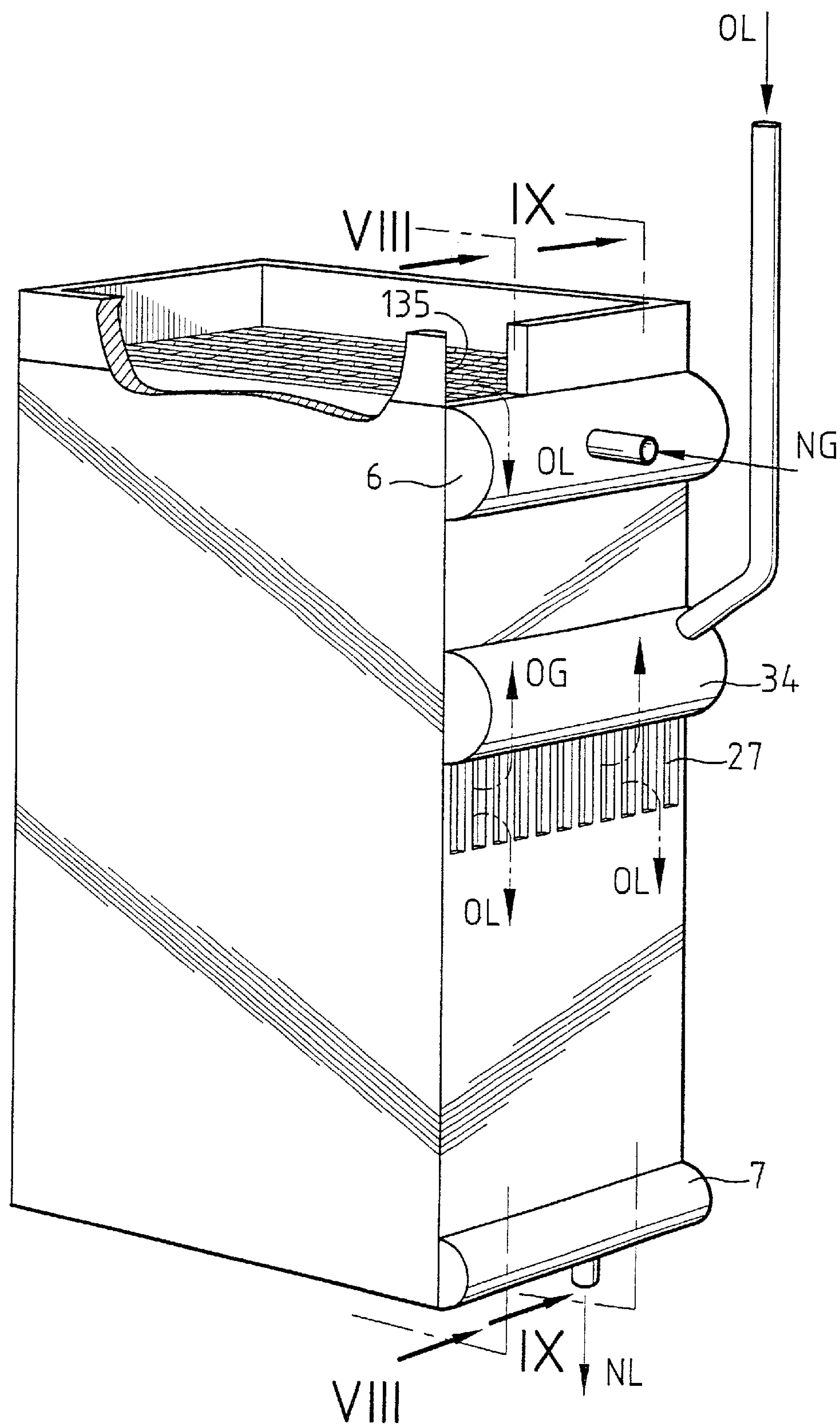



FIG.7

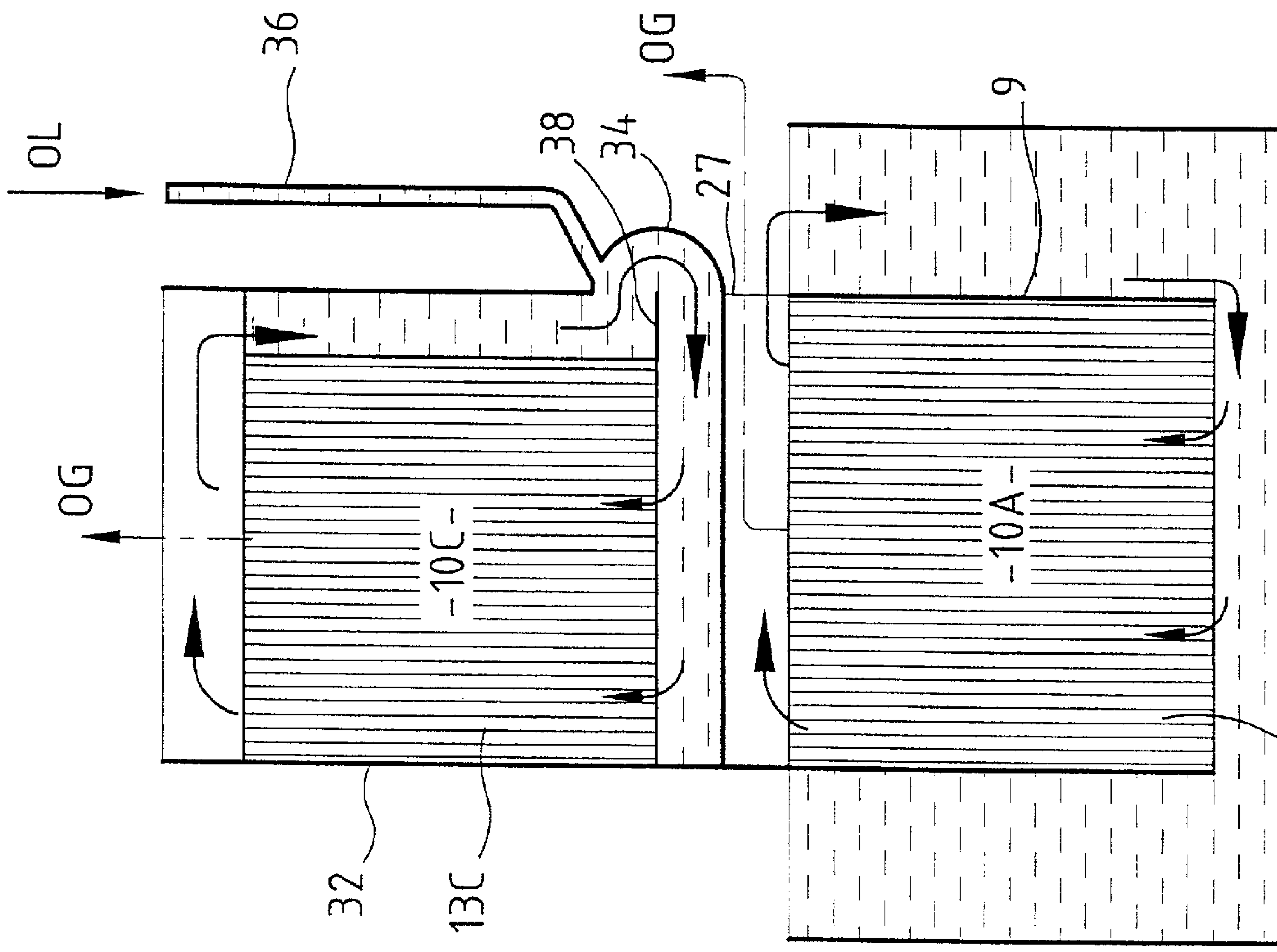

36
OL
38
34
OG
27
9
OG
-10C-
-10A-
13A
32
13C

FIG.9

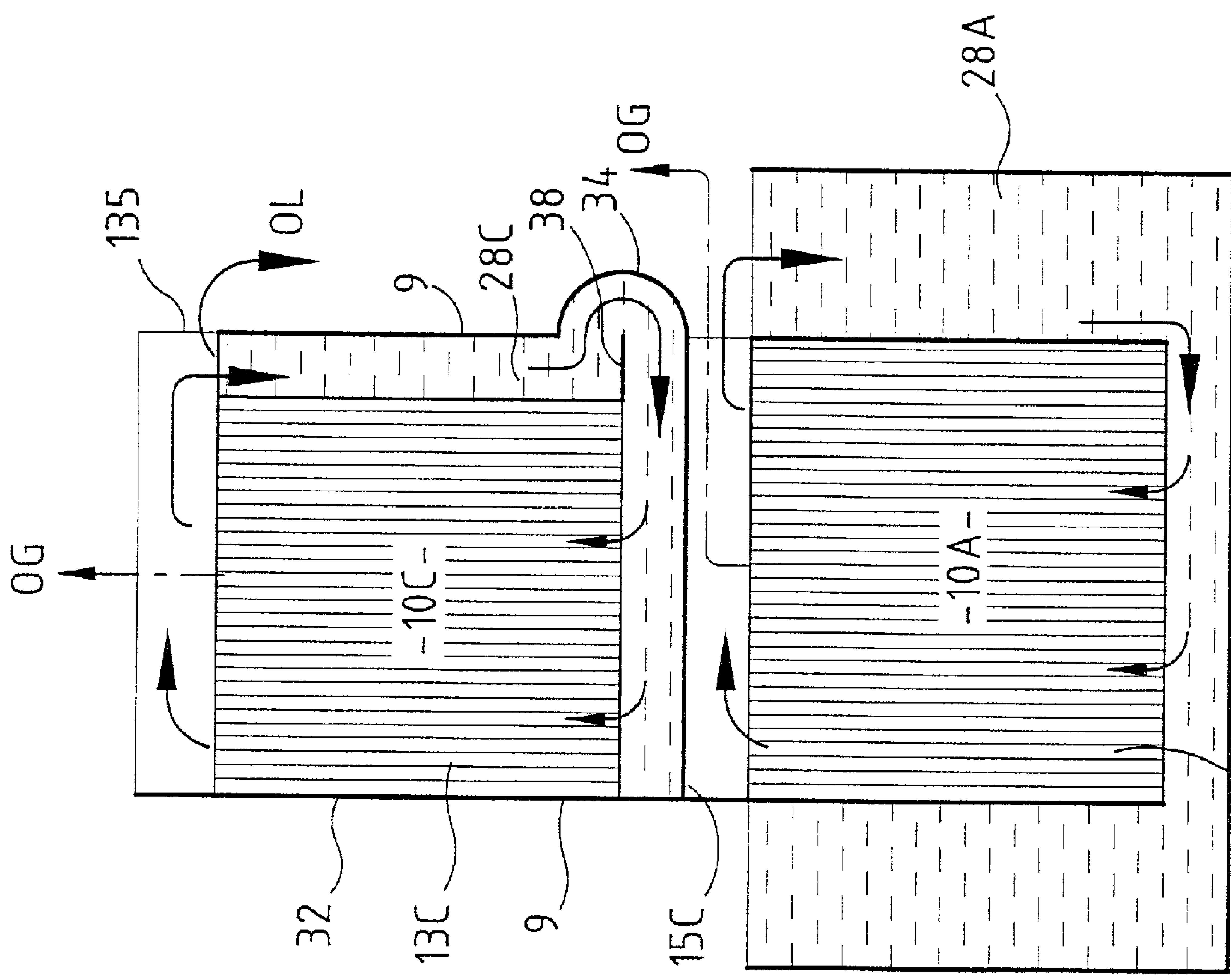

135
OL
9
28C
38
34
OG
28A
OG
-10C-
-10A-
13A
32
13C
9
15C

FIG.8

# BATH REBOILER-CONDENSER AND CORRESPONDING AIR DISTILLATION PLANT

The present invention relates to a bath reboiler-condenser, condenser, of the type comprising at least one exchanger body which comprises a stack of parallel plates, closure bars and spacer-waves which define a series of vaporization passages which are entirely open at their top and bottom ends, and a series of condensation passages.

The invention applies in particular to the main reboiler-condensers of air distillation plant which vaporize liquid oxygen at low pressure (typically a pressure slightly greater than atmospheric pressure) by condensing nitrogen at a medium pressure (typically an absolute pressure of 5 to 6 bars), and it will be explained hereinafter in that application.

Bath reboiler-condensers operate as a thermosiphon. The upward flow of the vaporizing oxygen is provided by the hydrostatic pressure due to the head of the liquid oxygen bath and to the reduction in weight of the vaporizing liquid.

For safety reasons, the recirculating liquid oxygen flow rate must be several times greater than the vaporized oxygen flow rate. For this reason, the head of the liquid oxygen bath must be approximately equal to the height of the exchanger, i.e. the exchanger is almost totally immersed in the liquid.

To reduce the temperature difference between the fluid which is condensing and the fluid which is vaporizing, in order to reduce the pressure of the heating nitrogen and therefore the energy required to compress the treated air, the heat-exchange area must be increased. Because the horizontal dimensions of the exchanger are limited by the space available in the bottom of the low-pressure distillation column, the height of the exchanger must be increased.

However, increasing its height increases the hydrostatic pressure of the liquid at the bottom of the column, i.e. at the inlet of the vaporization passages. This creates in the lower part of the exchanger a region containing undercooled free liquid and at least partially neutralizes the beneficial effect of increasing the heat exchange area.

The object of the invention is to improve the efficiency of the reboiler-condenser with a relatively simplified construction.

To this end, the invention provides a reboiler-condenser of the aforementioned type characterized in that the vaporization passages are subdivided by separator bars into at least two stacked vaporization regions each of which is entirely open at its bottom end and at its top end, each vaporization region being provided with a liquid recirculation corridor and overflow means at the top whereby the liquid overflows into an underlying vaporization region to create in each vaporization region a partial-height bath separated from the other bath(s) and in which said region is immersed to substantially all of its height, in that the top end of each bottom vaporization region and intermediate vaporization region is spaced vertically from the separator bar which supports the next higher bath, and in that the heat-exchanger body includes means for supplying liquid to the top vaporization region and means for evacuating vapor at each intermediate level between two vaporization regions.

The invention also provides air distillation plant including a main reboiler-condenser as defined hereinabove for vaporizing liquid oxygen by condensing nitrogen.

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:

FIG. **1** is a diagrammatic representation of part of air distillation plant according to the invention, which is shown in vertical section in a vaporization passage of the main reboiler-condenser;



FIG. **2** is an analogous view of the distillation plant shown in vertical section in a condensation passage of the main reboiler-condenser;

FIG. **3** is a view analogous to that of FIG. **1** of a variant;

FIG. **4** is a perspective view of another variant;

FIGS. **5** and **6** are views analogous to that of FIG. **1** and respectively in section taken along the lines V—V and VI—VI in FIG. **4**;

FIG. **7** is a view analogous to that of FIG. **4** of a further variant; and

FIGS. **8** and **9** are views analogous to that of FIG. **1** and respectively in section taken along the lines VIII—VIII and IX—IX in FIG. **7**.

The air distillation plant **1** of which a portion is shown in FIGS. **1** and **2** is a double distillation column consisting of a medium-pressure distillation column **2** on top of which is a low-pressure distillation column **3**. The nitrogen in the top of the column **2**, which operates at an absolute pressure of 5 to 6 bars, exchanges heat in the main reboiler-condenser **4** of the plant with liquid oxygen produced at the bottom of the column **3**. The column **3** operates at a pressure slightly greater than atmospheric pressure. To be more precise, the reboiler-condenser **4** vaporizes the liquid oxygen in the bottom of the low-pressure column by condensing gaseous nitrogen from the top of the medium-pressure column.

The reboiler-condenser **4** is fixed into the bottom of the shell of the low-pressure column **3** with a free space between it and the shell all around it. It comprises a single heat exchanger body **5** of the type with brazed plates and two semi-cylindrical boxes **6** and **7** welded to the body. The generally parallelepiped-shaped heat-exchanger body **5** comprises a stack of identical vertical rectangular aluminum plates **8**, closure bars **9** shown only as thick lines, separator bars described below, and spacer-waves **10** made of perforated corrugated sheet metal, for example. The assembly is brazed in a single operation in a furnace. The two boxes **6** and **7** are welded to the body **5** and comprise a top lateral box **6** for entry of gaseous nitrogen and a bottom lateral box **7** for exit of liquid nitrogen. Of course, the box **7** has an outlet for "non-condensables" (not shown).

Each pair of adjacent plates **8** delimits a generally flat passage. The passages are alternately oxygen vaporization passages **11** (FIG. **1**) and nitrogen condensation passages **12** (FIG. **2**). The bars **9** close the perimeter of the passages except for fluid inlet/outlet openings.

Thus the passages **11** are closed laterally over most of their height and totally open at their top and bottom ends.

On the other hand, the passages **12** are closed throughout their periphery except for a top lateral inlet for gaseous nitrogen which communicates with the box **6** and a bottom lateral outlet for liquid nitrogen which communicates with the box **7**.

Each vaporization passage **8** (FIG. **1**) is subdivided into a plurality of stacked vaporization regions, of which there are three in this example, namely a bottom vaporization region **13**A, an intermediate vaporization region **13**B and a top vaporization region **13**C. Each region **13**A to **13**C is substantially totally immersed in a bath of liquid oxygen and is defined by a respective rectangular wave **10**A to **10**C with vertical generatrices.

The wave **10**A of the bottom region **13**A extends across most of the horizontal width of the passage. On respective opposite sides of the wave, a liquid recirculation duct **14**A is delimited between the wave and the adjacent closure bar **9**.

The intermediate region **13**B is above and at a vertical distance from a horizontal bottom separator bar **15**B, which extends from one bar **9** (that on the right in FIG. **1**) to a point spaced from the opposite bar **9**. The region **13**B runs from the right-hand bar **9** to a point at a distance from a vertical retaining bar **16**B, which starts from the left-hand end of the bar **15**B. The wave **10**B is disposed in the space defined by the bars **15**B and **16**B. The top edge of the wave is substantially level with the top end of the bar **16**B and its bottom edge and the top bar **15**B delimit a source supply free space **17**B. In the horizontal direction, the wave **10**B starts from the right-hand bar **9** and terminates at point at a small distance from the bar **16**B, with which it delimits a liquid recirculation space **14**B.

The bar **15**B is spaced vertically from the top edge of the wave **10**A. This defines between the regions **13**A and **13**B a free space **19** which extends the full width of the heat exchanger body and which is connected to a liquid descent free space **18**B between the left-hand bar **9** and the bar **16**B.

The top vaporization region **13**C has the same structure as the region **13**B, but reversed left-to-right, with a bottom separator bar **13**C, a lateral retaining bar **16**C and a supply free space **17**C and a recirculation free space **14**C delimited by the wave **10**C. The bar **15**C is spaced vertically from the top edge of the wave **10**B, which defines between the regions **13**B and **13**C a free space **21** which extends the full width of the heat exchanger body. The space **21** is connected to a descent free space **18**C delimited between the bar **16**C and the right-hand bar **9**.

A supply weir **23** consisting of a horizontal bottom bar **24** and a short vertical lateral bar **25** is located above in the upper end region of the vaporization passage and at a distance from the region **13**C. The bar **24** starts from the right-hand bar **9** and the bar **25** is connected to the left-hand end of the bar **24** and is substantially vertically aligned with the bar **16**B. This defines a supply descent **26** between the bar **25** and the left-hand bar **9**.

The right-hand closure bar **9** defines a window **27** between the regions **13**A and **13**B and between the region **13**C and the weir **23**. The left-hand closure bar **9** defines an analogous window **27** between the regions **13**B and **13**C.

The waves **10** of the condensation passages **12** have vertical generatrices over most of the height of the passages and are extended upward and downward by oblique distribution waves which communicate with the lateral nitrogen inlet/outlet windows, in the conventional way.

In operation, a constant level mass of liquid oxygen is accumulated in the bottom of the column **3**. Its free surface is substantially level with the top edge of the wave **10**A, with the result that the wave is substantially totally immersed in a bottom partial-height bath **28**A of liquid oxygen.

The liquid oxygen produced by the column **3** is distributed substantially uniformly into the set of weirs **23**, as shown diagrammatically by the arrow F in FIG. **1**.

The liquid overflows and drops into the region **13**C, where it forms a top partial-height bath **28**C. The liquid oxygen is partly vaporized in this region. The excess liquid overflows over the bar **16**C into the space **18**C and drops into the region **13**B. The vaporized oxygen escapes from the heat-exchanger body in the column **3**, mostly via the top window **27**.

Similarly, in the region **13**B, the liquid oxygen forms an internal partial-height bath **28**B. Partial vaporization of the oxygen in the region **13**B forms gaseous oxygen which escapes from the heat exchanger body into the column **3** via the intermediate window **27**. The excess liquid overflows over the bar **16**B and drops into the bottom bath **28**A via the descent **18**B.

Partial vaporization of the oxygen in the bottom bath forms gaseous oxygen which escapes into the column **3** via the bottom window **27**. The excess liquid overflows and recirculates of its own accord into the bath **22**A via the descents **14**A.

Partial vaporization of the oxygen in each bath causes a flow of liquid by the thermosiphon effect, with recirculation via the spaces **14**A, **14**B and **14**C.

In the conventional way, gaseous nitrogen from the top of the column **2** enters the condensation passages **12** (FIG. **2**) via the top box **6** and then descends in the heat-exchanger body, progressively condensing as it travels its full height. The liquid nitrogen collects at the base and returns to the column **2** via the bottom box **7**.

In the FIG. **1** example, only the bottom vaporization regions **13**A of the various vaporization passages communicate with each other via the bottom bath **28**A. The other vaporization regions are isolated from their counterparts in the other passages. This calls for a distributor to distribute the liquid uniformly between the passages at the top of the reboiler-condenser, using appropriate means known in the art and not shown.

In the FIG. **3** example, on the other hand, means are provided for communication between all of the regions **13**B, on the one hand, and all of the regions **13**C, on the other hand. To this end, the reboiler-condenser is modified as follows:

- the weir **23** is eliminated;
- the bars **16**B and **16**C are eliminated and the waves **10**A to **10**C extend the full height of the passages **11**;
- the top window **27** in FIG. **1** is eliminated and windows **27** are provided on the right and on the left in the closure bars **9** between the regions **13**A and **13**B and between the regions **13**B and **13**C;
- the following are added throughout the thickness of the heat exchanger body, i.e. perpendicularly to the plane of the drawing:
  - on the right of the body **5**, a top trough **29**C which collects all of the liquid which overflows from the region **13**C and whose bottom part communicates with the space **17**C via an additional window **30**C in the right-hand bar **9**;
  - an intermediate trough **31** which caps the previous trough and collects all of the liquid that overflows from it; the bottom part of the trough **31** communicates with the right-hand window **27** between the windows **13**B and **13**C; and
  - on the left of the body **5**, a bottom trough **29**B which collects all of the liquid which overflows from the region **13**B and whose bottom part communicates with the space **17**B via an additional window **30**B in the left-hand bar **9**.

Accordingly, in operation, the liquid oxygen can drop directly onto the heat exchanger body, as shown diagrammatically by the arrow F in FIG. **3**. It forms the top bath **28**C on being divided between all of the regions **13**C via the trough **29**C. From there, the liquid overflows into the trough **31** to feed the intermediate bath **28**B and is distributed between all of the regions **13**B via the trough **29**B. From there, the liquid overflows into the bottom bath **28**A.

The gaseous oxygen produced by vaporization enters the column **3** via the two bottom windows **27**, via the two top windows **27** and via the top opening of the passages **11**, across their full width.

In the embodiment shown in FIGS. **4** to **6**, the lateral face **32** of the reboiler-condenser, consisting of edges of plates and closure bars **9**, has no openings or accessories. This enables two identical reboiler-condensers to be placed together back-to-back.

The following are provided on the opposite lateral face, from the bottom upwards:

the liquid nitrogen outlet box **7**;

a horizontal row of identical windows **27** through which liquid oxygen overflows and vaporized gaseous oxygen is evacuated from the bottom region **13**A;

a semi-cylindrical box **33** extending the full thickness of the reboiler-condenser for feeding all the intermediate regions **13**B and for mixing liquid;

a row of windows consisting, in the left-hand part (as seen in FIG. **4**) of the thickness of the reboiler-condenser, windows **27** for evacuating gaseous oxygen vaporized in the region **13**B and, in the right-hand part of said thickness, windows **127** for evacuating gaseous oxygen and overflow of liquid oxygen; the windows **27** and **127** have their top edges at the same level but the windows **127** are higher;

a semi-cylindrical box **34** for feeding liquid to all the top regions **13**C; this box extends the full thickness of the reboiler-condenser;

the gaseous nitrogen inlet box **6**; and

a semi-cylindrical box **35** for overflow of liquid from all the top regions **13**C; this box extends over only the left-hand part of the thickness of the reboiler-condenser.

A liquid supply pipe **36** of the reboiler-condenser terminates in the box **34**, near its right-hand end, and a liquid supply pipe **37** of the region **13**B connects the box **35** to the box **33**, near its left-hand end.

As can be seen in FIGS. **5** and **6**, the region **13**A extends the full width of each vaporization passage **11** and each region **13**B, **13**C starts from the left-hand bar **9** (FIGS. **5** and **6**) and leaves a recirculation space **14**B, **14**C between it and the right-hand bar **9**. The windows **27** and **127** are just below the separator bars **15**B and **15**C. The bottom windows **27** extend downward as far as the top of the region **13**A and the windows **127** extend downward as far as the top of the region **13**B.

The bottom generatrix of the box **33** is at the same level as the bar **15**B, that of the box **34** at the same level as the bar **15**C (FIG. **6**), and that of the box **35** is substantially level with the top of the region **13**C. As in FIG. **3**, the latter is totally open at the top, like the regions **13**A and **13**B.

A section of horizontal bar **38**, forming a chicane, is provided halfway up the height of each box **33** and **34** and at the level of the lower edge of the corresponding wave **10**B, **10**C.

In operation, the top regions **13**C are source fed via the pipe **36** and the box **34**. The level is equalized in all the regions **13**C and the recirculating liquid is mixed with fresh liquid at the top of that region and via the box **34**.

The liquid that overflows from the regions **13**C passes via the box **35** and the pipe **37** into the box **33** where it is mixed with the liquid recirculating in each region **13**B.

The liquid which overflows from the regions **13**B passes through the bottom part of the windows **127** and drops directly into the bottom bath **28**A (FIG. **6**).

Note that, in the regions **13**B and **13**C, the supply of liquid and the overflow occur at opposite points relative to the direction of the thickness of the reboiler-condenser. This encourages mixing of the recirculating liquid with the fresh liquid, so reducing the risk of local concentration of pollutants. Mixing is further encouraged by the bars **38**.

The variant shown in FIGS. **7** to **9** corresponds essentially to the previous embodiment with the intermediate stage **13**B eliminated. In a simplified embodiment of this kind, the pipe **37** and the box **35** are replaced by a simple notch **135** formed in the left-hand part of the top liquid retaining wall, and it is no longer necessary to provide two types of windows: the windows **27**, which are necessary only for the bottom stage, are all the same height and are used both for overflow of liquid oxygen and evacuation of gaseous oxygen.



What is claimed is:

**1**. A bath reboiler-condenser, of the type comprising at least one heat-exchanger body **(5)** which comprises a stack of parallel plates **(8)**, closure bars **(9)** and spacer-waves **(10)** which define a series of vaporization passages **(11)** entirely open at the bottom end and at the top end and a series of condensation passages **(12)**, characterized in that the vaporization passages are subdivided by separator bars **(15, 16)** into at least two stacked vaporization regions **(13A** to **13C)** each of which is entirely open at its bottom end and at its top end, each vaporization region being provided with a liquid recirculation corridor **(14A** to **14C)** and overflow means **(16B, 16C; 29B, 29C; 27, 35, 127)** at the top whereby the liquid overflows into an underlying vaporization region **(27)** to create in each vaporization region a partial-height bath **(28A** to **28C)** separated from the other bath(s) and in which said region is immersed to substantially all of its height, in that the top end of each bottom vaporization region **(13A)** and intermediate vaporization region **(13B)** is spaced vertically from the separator bar **(15B, 15C)** which supports the next higher bath, and in that the heat-exchanger body **(5)** includes means for supplying liquid to the top vaporization region **(13C)** and means **(27; 27, 127)** for evacuating vapor at each intermediate level between two vaporization regions **(13A–13B, 13B–13C)**.

**2**. A reboiler-condenser according to claim **1**, characterized in that said vapor evacuation means include vapor evacuation openings **(27; 27, 127)** defined by the lateral closure bars **(9)** at each intermediate level between two vaporization regions **(13A–13B, 13B–13C)**.

**3**. A reboiler-condenser according to claim **1**, characterized in that the bottom separator bar **(15B, 15C)** of each vaporization region is connected at one end to a lateral closure bar **(9)** of the vaporization passage **(11)** and in that the overflow means are on the opposite side of that passage.

**4**. A reboiler-condenser according to claim **1**, characterized in that the recirculation corridor **(14A** to **14C)** is inside the vaporization passage **(1)**, in particular between the vaporization region **(13A** to **13C)** and a lateral closure bar **(9)** of said passage.

**5**. A reboiler-condenser according to claim **1**, characterized in that each bottom separator bar **(15B, 15C)** extends over only a part of the width of the vaporization passage **(11)** and in that the overflow means of at least one vaporization region **(13B, 13C)** are formed by a retaining bar **(16B, 16C)** inside the vaporization passage which forms a weir.

**6**. A reboiler-condenser according to claim **1**, characterized in that the intermediate vaporization regions **(13B)** or top vaporization regions **(13C)** of each vaporization passage **(11)** do not communicate with those of the other vaporization passages and in that said liquid supply means are adapted to divide the liquid substantially uniformly between the vaporization passages **(11)**.

**7**. A reboiler-condenser according to claim **1**, characterized in that at least one intermediate region **(13B)** or top region **(13C)** communicates with a counterpart region of all the other vaporization passages via a lateral channel **(29B, 29C; 33)** which extends across the thickness of the reboiler-condenser **(1)**.

**8**. A reboiler-condenser according to claim **7**, characterized in that said lateral channel **(29B, 29C)** forms a liquid recirculation trough.

9. A reboiler-condenser according to claim 7, characterized in that said lateral channel (29B, 29C) forms the overflow means.

10. A reboiler-condenser according to claim 1, characterized in that the overflow means include a duct (37) laterally of the heat exchanger body (5) which connects a top point of one vaporization region (13C) to a bottom point of the underlying vaporization region (13B).

11. A reboiler-condenser according to claim 1, characterized in that, for at least one vaporization region (13B, 13C), the overflow means (35, 127) start from a location which is opposite a bottom liquid supply point of that region relative to the direction of the thickness of the heat exchanger body (5).

12. A reboiler-condenser according to claim 1, characterized in that, for at least one vaporization region (13B, 13C), the overflow means (16B, 16C; 29B) are on the opposite side of that region relative to the direction of the width of the passage to the location (18C, 26; 31) where that region is supplied with liquid.

13. A reboiler-condenser according to claim 1, characterized in that, at the top end of at least one vaporization region (13A, 13B), the lateral bars (9) of the vaporization passages (11) define a row of vaporized fluid evacuation windows (27, 127), at least some of which also form said overflow means.

14. A reboiler-condenser according to claim 13, characterized in that said part (127) of the row of windows is higher than the other windows of that row.

15. A reboiler-condenser according to claim 1, including at least three vaporization regions (13A to 13C), characterized in that the overflow means (16B, 16C; 29B, 29C) are alternately on one side and the other side of the vaporization passage (11).

16. A reboiler-condenser according to claim 1, characterized in that the overflow means (27, 35, 127) are all on the same side of the vaporization passages (11) and the opposite lateral face (32) of the heat exchanger body (5) is plane.

17. A reboiler-condenser according to claim 16, characterized in that it includes two heat-exchanger bodies (5) in contact at their plane lateral faces (32).

18. Air distillation plant including a reboiler-condenser for vaporizing liquid oxygen by condensing nitrogen, characterized in that the reboiler-condenser includes at least one heat-exchanger body (5) which comprises a stack of parallel plates (8), closure bars (9) and spacer-waves (10) which define a series of vaporization passages (11) entirely open at the bottom end and at the top end and a series of condensation passages (12), characterized in that the vaporization passages are subdivided by separator bars (15, 16) into at least two stacked vaporization regions (13A to 13C) each of which is entirely open at its bottom end and at its top end, each vaporization region being provided with a liquid recirculation corridor (14A to 14C) and overflow means (16B, 16C; 29B, 29C; 27, 35, 127) at the top whereby the liquid overflows into an underlying vaporization region (27) to create in each vaporization region a partial-height bath (28A to 28C) separated from the other bath(s) and in which said region is immersed to substantially all of its height, in that the top end of each bottom vaporization region (13A) and intermediate vaporization region (13B) is spaced vertically from the separator bar (15B, 15C) which supports the next higher bath, and in that the heat-exchanger body (5) includes means for supplying liquid to the top vaporization region (13C) and means (27; 27, 127) for evacuating vapor at each intermediate level between two vaporization regions (13A–13B, 13B–13C).

* * * * *